Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	
Review of the Section 251 Unbundling Obligations Of Incumbent Local Exchange Carriers	CC Docket No.01-338
Implementation of the Local Competition Provisions of the Telecommunications Act of 1996	CC Docket No. 96-98
Deployment of Wireline Services Offering Advanced Services Capability	CC Docket No. 98-147

Comments of

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[1] **Disclaimer:** The institutional affiliation is for identification purposes only. The following views are those of the authors and do not necessarily represent the views of Carnegie Mellon University or its Department of Engineering and Public Policy

1 Introduction

These reply comments are submitted in response to the Notice of Proposed Rulemaking (FCC 01-361) released on December 20, 2001. In this Notice, the Federal Communications Commission (FCC), among other things, seeks to identify precisely how incumbent local exchange carriers (ILECs) should provide requesting carriers, access to their 'last mile' fiber network on an unbundled basis. Given that there seems to be renewed interest in 'fiber in the last mile', this notice is indeed very timely. With ILECs, and municipalities, among other private and public entities considering building Fiber to the Home (FTTH) infrastructure in the near future, this seems like the right time to examine the issue of 'Competition in the last fiber mile' in more detail. In this document we summarize the conclusions of our ongoing research at Carnegie Mellon University. For a more detailed understanding of FTTH architectures, economics and competition, the reader is directed to the viewgraphs in Appendix 1.

2 Models for Competition in 'Fiber in the Last Mile'

Competition in the telecommunications services industry (and therefore in FTTH) can be facilities based or non-facilities based; the Telecommunications Act of 1996 contemplates both forms of competition.

2.1 Facilities based Competition

Under this arrangement, each service provider serves the market using its own physical network (Figure 2.1). In the FTTH context that would imply that each service provider builds out its own FTTH network.

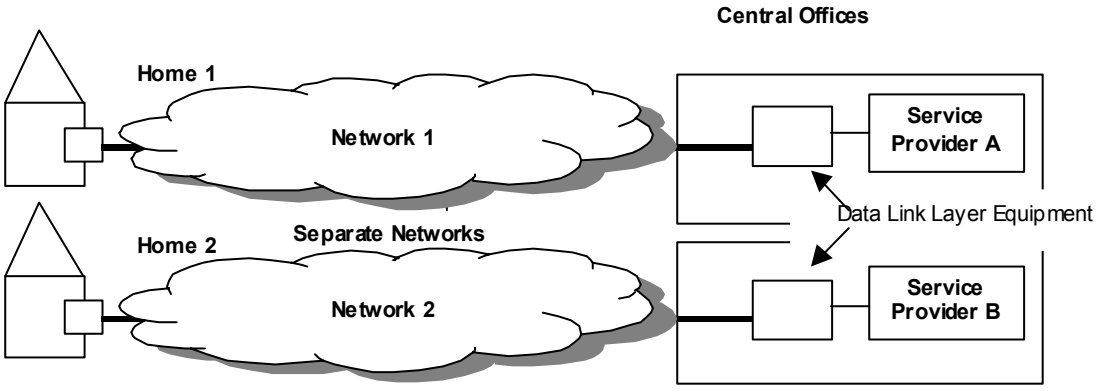

Figure 2.1 Facilities based competition

2.2 Non-Facilities based Competition or Service level Competition

In this context, each service provider does not have a separate network but shares the resources of a common network to provide service to its customers. Depending on the nature of resource sharing by the competitors, non-facilities based competition can have the following models:

2.2.1 'Unbundled Network Elements (UNE)' based Model for Competition: Each service provider can co-locate its data-link layer equipment at the CO and offer voice, data, video and data-link layer services to its customers by renting 'unbundled network elements[2]' (like a 'dark fiber' loop) from the network owner (Figure 2.2). It is important to note that the shared FTTH network should be amenable to 'physical plant unbundling[3]' for UNE based competition to be possible. Clearly the network owner does not deploy any active electronics, unless it is also in the business of providing retail voice, video and data services. The local telephone service industry exhibits this model of competition with CLECs (Competitive Local Exchange Carriers) renting UNEs from the Incumbents to provide telephone service.

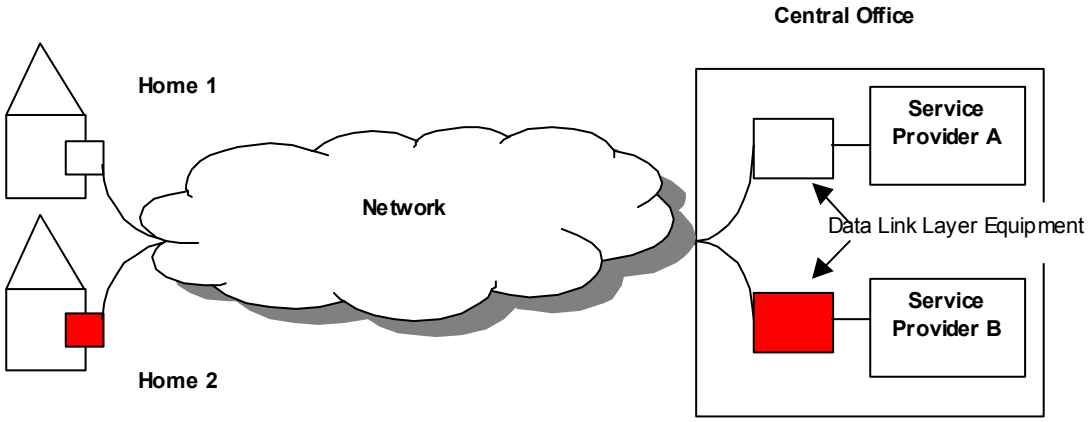

Figure 2.2 UNE based Competition

[2] We would like to point out at this stage that a UNE in a FTTH network should refer to 'dark fiber' and not logical unbundling of data-link-layer services.

[3] An easy way to understand this is that the Cable TV network, because of the extensive sharing of physical cable is NOT amenable to physical plant unbundling and hence cannot support UNE based competition. By contrast, a copper pair network with individual pairs between the Central Office and the subscriber does support UNE based competition today.

2.2.2 'Open Access' based Model for Competition: Each service provider has to connect to common data-link layer equipment (generally belonging to the network owner) in order to provide voice, video and data services (Figure 2.3). The shared network, in this case, is unbundled at the 'logical layer'. This is the only way[4] to have competition in networks where the physical plant cannot be unbundled. A typical example of this type of competition is the various ISPs that provide broadband Internet services over a single Cable network.

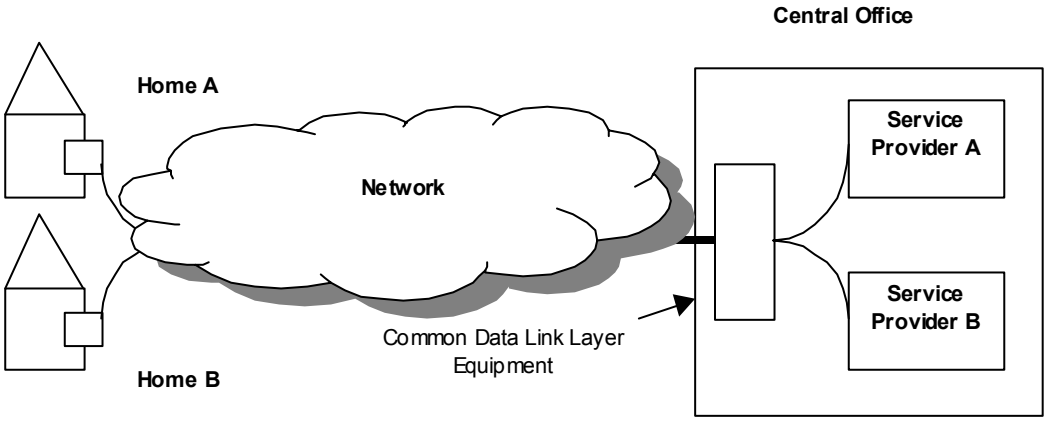

Figure 2.3 Open Access based Competition

3 Why should it be mandatory for ILECs to unbundle their FTTH network?

Our engineering cost models for different architectures (Home Run Fiber, PON, Active Star and WDM PONs) across different deployment scenarios (Urban, Suburban, Small Town, Rural and Remote Rural) clearly show that FTTH is a decreasing cost infrastructure (Figure 3.1). Note that the capital cost per home at 30% penetration is almost double the cost per home at a 100% penetration indicating that it is difficult for a market to support multiple infrastructures.

[4] If the shared network runs multiple wavelengths, unbundling can also happen at the 'wavelength (or optical) layer'. Two models of wavelength-based competition are possible: (i) Wavelength per subscriber and (ii) Wavelength per Service Provider. Since, our engineering economic analysis reveals that multiple wavelength FTTH networks are unlikely to be economically viable in the near future, we do not discuss this option further here.

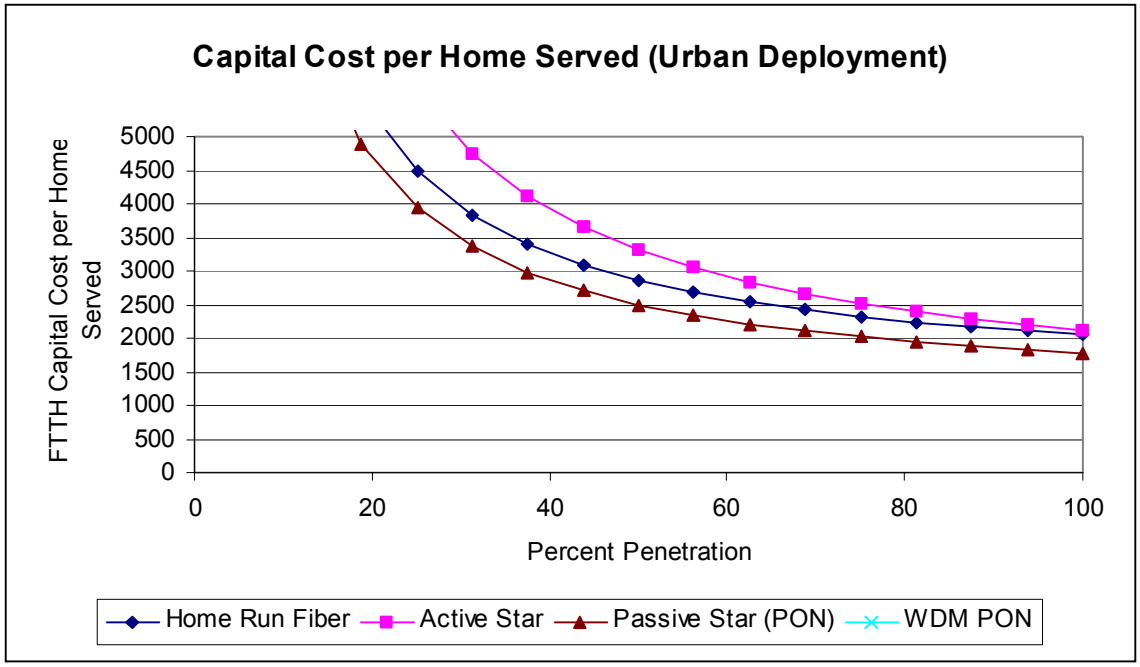

Figure 3.1 Capital Cost per Home Served

Though one cannot conclude from the above figure whether FTTH is a natural monopoly infrastructure, it is safe to conclude that it is unlikely that there will be any more than two FTTH networks serving the same community and that a majority of communities will have only one network.

Given the strong natural monopoly trends that this infrastructure exhibits, facilities based competition can be virtually ruled out in this industry. In the absence of ILECs being obliged to provide UNEs, the ILECs will monopolize voice and data services and there will be at best a duopoly with cable.

4 Why is UNE based Competition preferable to Open Access Competition?

'Open Access' based competitive provisioning of Voice, Data and Video services over a shared transport network is made possible by 'unbundling' the network at the 'logical layer' and the 're-sale' of data-link layer services. However, this extends the physical plant monopoly to a monopoly in the provision of data link layer services. The primary disadvantage of this is the fact that all services have to run over the common data link layer selected by the network owner, even though there may be some customers who would prefer an asynchronous transfer mode (ATM) data link layer and others who might prefer Gigabit Ethernet technology at the data link layer.

The lack of competitive provisioning of data link layer services may not only limit the evolution of data link layer technology, but more importantly, voice, video and data service possibilities may be limited by the capabilities of the chosen data link layer[5]. Finally, it does not seem easy to police the quality of service provided to each of the competitors who have 'open access'.

UNE based competition leads to competitive provisioning of data link layer services and creates a competitive market for transport services. It permits a voice, video and data service provider to choose what data link layer technology to deploy and provides the end-user with a choice of service providers using different data link layer technology.

5 Architectures and Competition

While it is certainly desirable to have UNE based competition, it is important to point out that not all FTTH architectures can support 'physical plant unbundling' and UNE based competition. The 'curb-side' PON[6] can only be unbundled at the logical layer and therefore supports open access based competition only. On the other hand, dark fiber UNEs are easy to provision in Home Run[7] architectures.

Our research shows that, physical plant unbundling is possible in PONs by establishing Optimized Fiber Aggregation Points (OFAPs) that aggregate multiple passive optical splitters (Figure 5.1). Unbundling is achieved at the cost of longer distribution loop lengths. OFAP architectures further lead to higher utilization of splitter and Optical Line Termination (OLT) ports in markets that have less than 100% penetration resulting in cost savings (due to deferred investments) in splitter and OLT ports and increased flexibility in service roll-out under both monopoly and competition. In deploying fiber to the home, ILECs may be tempted to design the deployed PON architectures in a way, which eliminates the potential for competition based on unbundled dark fiber elements. Some of our preliminary results show, however, that the minimum cost fiber network architecture - taking into account progressive adoption - results in an architecture (the OFAP PON) which is, in fact, hospitable to Unbundled Network Element (UNE) competition. Thus, deployment by ILECs of curb-side PON architectures, which frustrate competition, raises costs to competitors without providing any savings to the incumbent or its customers.

[5] A simple case in point is that competitive broadband ISPs that provide (or seek to provide) voice over IP services on a cable modem network, cannot do so unless and until the cable operator upgrades the data link layer equipment to support the necessary Quality of Service guarantees.

[6] In a curb-side PON the splitter is located as close to the homes as possible in order to minimize the total amount of fiber.

[7] In Home Run architecture each home is supported on a single dedicated strand of fiber from the Central Office.

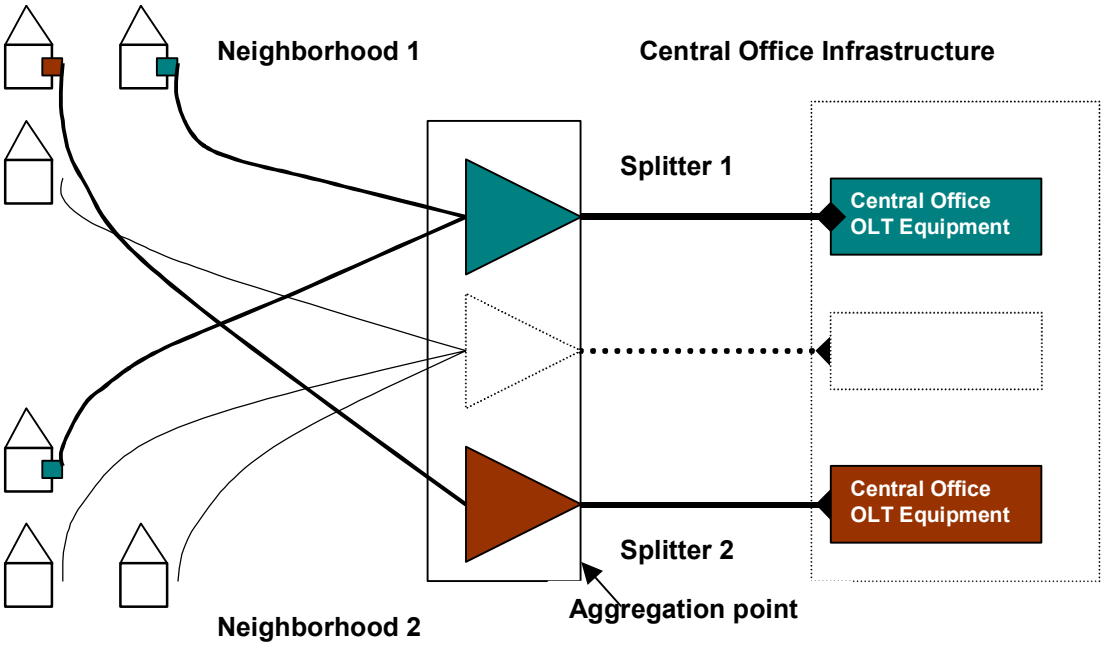

Figure 5.1 An OFAP PON: supports to UNE based Competition

6 CMSG's Study Which Purport to Show FTHH Unbundling to be Uneconomic is Seriously Flawed

Our comments here are based on extensive modeling of the engineering economics of broadband local access systems, undertaken over the last 15 years.[8] While we have not had the opportunity to examine all of the filed comments, we would like to comment specifically on the study conducted by the Cambridge Strategic Management Group (CSMG) and included in the comments filed by Corning, Inc. CSMG's analysis, which purports to show that requiring UNEs inevitably leads to lower levels of ILEC investment in FTTH, is in our opinion, fatally flawed.

First, the study is not a study of fiber UNEs at all. It is a study of wholesale sales of data link layer services. That is, it presumes that the owner of the dark fiber facility is the sole provider of data link layer services over that fiber, and provides Open Access to these services to other higher layer service providers. The model assumes that the ILEC supplies all of the Customer Premises Equipment (CPE) and the Host Digital Terminal

[8] Sirbu, M., Reed, D. and Ferrante, F., "An Engineering and Policy Analysis of Fiber Introduction into the Residential Subscriber Loop," *Journal of Lightwave Technology,* November, 1989., Omoigui, N., Sirbu, M., Eldering, C. and Himayat, N., "Comparing Integrated Broadband Architectures from an Economic and Public Policy Perspective" in *Telecommunications and Internet Policy,* Brock, G., ed. (Lawrence Erlbaum: Washington, DC, 1996), Fryxell, D., Sirbu, M. and Wanichkorn, K., "An IP-based Local Access Network: Economic and Public Policy Analysis," in Gillett, S. and Vogelsang, I. eds, *Competition, Regulation, and Convergence : Current Trends in Telecommunications Policy Research* (Mahwah, N.J.: Lawrence Erlbaum Assoc, 1999)

(HDT), which must be used by a CLEC which therefore interconnects only at the logical layer. In this respect it does not at all correspond to a true UNE, or dark fiber lease.

Even as a study of logical layer unbundling, the report's conclusions are based on biased assumptions. The biggest single error is the assumption that the penetration rate when only the ILEC offers service is exactly the same as the penetration rate when multiple service providers are competing to market services. That is, they assume that the services market is a zero-sum game, as opposed to the conventional assumption when analyzing competitive markets: namely that the additional product variety introduced by competitors (*e.g.* CLECs) leads to greater demand and consumption of FTTH services. It is equivalent to the 1960s argument by the old AT&T monopoly, that it alone could provide all the variety that customers could ever want, and therefore there was no reason to permit new entrants into the CPE or long distance markets. In fact, the presence of CLECs in the market will most assuredly lead to higher levels of wholesale FTTH sales than could be realized if only the ILEC is offering retail services over the fiber. For example, retail competition should drive down prices for retail services, thus leading to increased demand. In particular, CSMG totally discounts the possibility that an existing cable provider might choose to buy fiber UNEs rather than continue to use/upgrade/maintain their coaxial cable plant, an alternative which would greatly increase the wholesale usage of any FTTH investment. Without UNEs, a cable operator would have no choice but to continue to rely on its own plant, and thus keep their customers from contributing to the support of an ILEC-built FTTH infrastructure.

The addressable market for FTTH is substantially underestimated in all scenarios. CSMG seem to have arbitrarily limited addressable houses to those that are within the ADSL limits of 12 kilo feet, or 60% of the CO whichever is larger. There is no technological nor economic basis for such a limitation, as fiber networks can easily carry signals tens of kilometers.

CSMG may also have overestimated revenues, both with, and without unbundling, by assuming that all telephone lines supplied over fiber earn the same revenue as existing telephone lines. However, cable and DSL based "second line" offerings using VoIP will drive down the Average Revenue Per User (ARPU) for voice lines over the time horizon of their analysis.

Finally, the model arbitrarily underestimates the revenues that an ILEC can earn from providing wholesale access to data link layer services over the fiber. Under the FCC's rules, UNE's are supposed to be priced at TELRIC levels. Because this is new investment, Total Element Long Run Incremental Costs are at least equal to the capital expenditure, which they estimate as $2200 per household. If the cost of capital is 13%, then the appropriate TELRIC price using a 15-year lifetime[9] is $27.84. Even assuming a 40-year life, it would still be $23.97. The 1% per month number that they use is pulled out of thin air.

[9] Fifteen years is a reasonable average of the long fiber lifetime, and the much shorter lifetimes of CPE and HDT equipments.

In short, the CSMG model cannot in any way be relied upon as providing an unbiased estimate of the economic consequences of requiring ILECs to provide logical layer unbundling of FTTH networks and data link layer services. And it does not even attempt to examine the economics of true unbundling at the dark fiber level.

7 Conclusions

In conclusion, we believe that the Commission should carefully examine the merits of requiring ILECs—or any first mover provider of FTTH—to provide access to dark fiber on an unbundled network element basis as a means of assuring competition in *both* data link layer and higher layer services.

Appendix 1